JAPANESE PATENT OFFICE (JP)

PATENT JOURNAL (A)

KOKAI PATENT APPLICATION NO. HEI 7[1995]-198953

Technical Indication Section		
Int. Cl.^{6}:	G 02 B	6/00 5/02
Identification code:	326 B	
Sequence Nos. for Office Use:	FI	
Application No.:	Hei 5[1993]-354593	
Application Date:	December 28, 1993	
Publication Date:	August 1, 1995	
No. of Inventions:	2 FD (Total of 4 pages)	
Examination Request:	Not requested	

A LIGHT-EMITTING MATERIAL

[Hakkohtai]

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[*There are no amendments to this patent.*]

(54) [Title of the invention]

A light-emitting material

(57) [Abstract]

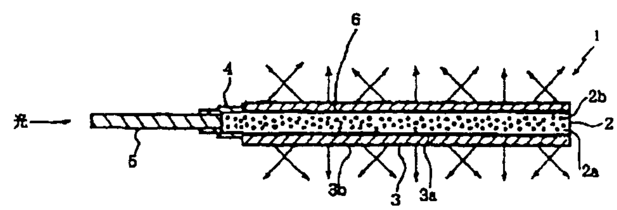
[Constitution] A light-emitting material wherein a light-scattering body (2) consisting of a transparent matrix (2a) and transparent material having a different refractive index from that of the matrix is uniformly dispersed in the matrix, is inserted into light

transmitting cylinder (3) having an inner diameter greater than that of the outer diameter of the above-mentioned light-scattering body (2) and at least either the inner wall or the outer wall or both walls of the above-mentioned cylinder have rough surfaces and the rays of light entering from one end are emitted over the entire peripheral surface .

[Effect] Uniform emission of light in all directions and uniform emission of light as a whole can be achieved in the light-emitting material of the present invention.

[Explanation of codes]

1	Light-emitting material
2	Light-scattering body
2a	Transparent matrix
2b	Transparent material
3	Transparent cylinder body
3a	Cylinder inner surface
3b	Cylinder outer surface
4	Joint
5	Optical transmission tube



[Claims of the invention]

[Claim 1] A light-emitting material wherein a light-scattering body consisting of a transparent matrix, a transparent material having a different refractive index from that of the matrix is uniformly dispersed in the above matrix, is inserted into a light transmitting cylinder having an inner diameter greater than that of the outer diameter of the above-

mentioned light-scattering body and at least either the inner wall or outer wall or both walls of the above-mentioned cylinder have roughened surfaces, and the rays of light entering from one end are emitted over the entire peripheral surface.

[Claim 2] The light-emitting material specified in claim 1 above wherein the shape of the light-scattering body is either a column or a cylinder.

[Detailed explanation of the invention]

[0001]

[Field of industrial application] The present invention pertains to a light-emitting material connected to the end of an optical transmission tube, etc. and capable of scattering and uniformly emitting rays of light transmitted through the optical transmission tube, and which can be effectively used for applications such as decorative lighting, underwater lighting, explosion proof lighting, and displays.

[0002]

[Prior art and problems to be solved by the invention] In the past, a lighting method wherein a light-scattering body is connected to the end of an optical transmission tube or optical fiber via a connection and rays of light from the optical tube or optical fiber are transmitted to the light-scattering body, and the rays of light transmitted to the light-scattering body are emitted over the entire peripheral surface of the light-scattering body has been known, and the above-mentioned system is widely used for decorative lighting, underwater lighting, explosion proof lighting, displays, etc.

[0003] In this case, the above-mentioned light-scattering body is made of a transparent matrix uniformly dispersed with a transparent material having a refractive index

different from that of the light-scattering body, and has a structure consisting of, for example, a methacrylate resin with a spherical silicone resin dispersed in it, and the above-mentioned material is formed into a rod, sphere, polygon, sheet, etc.

[0004] In the above-mentioned light-scattering body, the transparent matrix itself produces total internal reflection at the boundary with air, and the rays of light are transmitted without leaking from the body, but light-scattering occurs at the boundary with the transparent material uniformly dispersed in the above-mentioned matrix, and a component with an angle that does not adequately satisfy the total internal reflection criteria at the boundary between the transparent matrix and air is produced, and that light is emitted from the peripheral surface; thus, rays of light are emitted from the whole light-emitting material.

[0005] However, the distribution angle of the scattered light of the light-emitting material is known to have a high forward scattering angle when multiple scattering can be ignored. The above-mentioned high forward scattering phenomenon is more obvious when the light-emitting material has a column or cylindrical shape, the emitted light has a high proportion of component with a lower angle for the incident direction and in the case of a column shaped light-scattering body that emits light from the peripheral surface, it is very bright when observed from the diagonal direction from the front, but the luminance is reduced when observed perpendicular to the peripheral surface, and appears to be dark. In the case when the light-scattering body is used for the purpose of lighting, it is not desirable when the brightness varies depending on the angle from which viewed, and uniform emission in all directions is required.

[0006] The present invention is based on the above background, and the objective is to produce a light-emitting material capable of emitting, and diffusing the rays of light entering the light-scattering body and is capable of emitting light uniformly in all directions.

[0007]

[Means to solve the problem and effect] In order to achieve the above-mentioned objective, the present invention is a light-emitting material wherein a light-scattering body consisting of a transparent matrix and transparent material having a different refractive index from that of the matrix is uniformly dispersed in the matrix, is inserted into a light transmitting cylinder having an inner diameter greater than that the outer diameter of the above-mentioned light-scattering body, and at least either the inner wall or the outer wall or both walls of the above-mentioned cylinder have a roughened surface, and the rays of light entered from one end are emitted from the entire peripheral surface.

[0008]

[Effect] In the light-emitting material of the present invention, an optical transmission tube or optical fiber (light source) is connected to one end of the light-scattering body inserted into a light transmitting cylinder, and the transmitted light is scattered by the transparent material uniformly dispersed in the transparent matrix and the rays of light are emitted from the whole peripheral surface of the light-scattering body, the inner diameter of the cylinder is greater than the outer diameter of the light-scattering body, and the light-scattering body is covered with a light transmission tube having roughened surfaces for either or both the inner surface and the outer surface; thus, the above-mentioned localized scattering of light is less likely to occur, and even when localized scattering of light does

occurs, the light transmission tube that covers the above-mentioned light-scattering body exhibits a higher diffusion of light, as a result, the rays of light transmitted through the light transmission tube are diffused in all directions; as a result, the rays of light from the light transmission tube are emitted in all directions and a light-emitting material with uniform brightness can be produced.

[0009]

[Application examples] In the following, an application example of the present invention is explained in specific terms with reference to Fig. 1. Light-emitting material 1 shown in Fig. 1 is a structure consisting of a cylindrical light-scattering body 2 and light transmission tube 3 having a roughed surface on either or both the inner surface and the outer surface with a cylinder shape that covers the above-mentioned light-emitting material, and one end of the light-scattering body 2 is connected to optical transmission tube 5 via joint 4.

[0010] The above-mentioned light-scattering body 2 has a structure consisting of a material produced by uniformly dispersing in transparent matrix 2a a transparent material 2b having a different refractive index from that of the transparent matrix. In specific terms, for examples of transparent matrix 2a, organic resins such as polymethyl methacrylate, polycarbonate, silicone, and polystyrene, and inorganic materials such as glass, quartz, and transparent ceramics, can be used, and for transparent material 2b, organic powders such as polymethyl methacrylate, polycarbonate, polystyrene, and silicone resin, and inorganic powders such as calcium carbonate, titanium oxide, glass, silica, and ceramic powders having a transparent monocrystal, and furthermore, gases, air bubbles, vacuum voids, etc.

can be used. In this case, a spherical material is desirable, and the mean particle diameter is in the range of 0.01 to 20 μm, and in the range of 0.1 to 10 μm is especially desirable. In general, the amount of transparent material dispersed is in the range of 0.001 to 50 parts by weight, preferably, in the range of 0.005 to 1 part by weight. As a suitable specific example, a material produced by mixing 0.005 to 0.5 parts of spherical silicone resin with a mean particle diameter in the range of 0.1 to 10 μm with 100 parts of a transparent matrix made of polymethyl methacrylate, a material produced by mixing 0.005 to 0.5 parts by weight of a powder with a mean particle diameter in the range of 0.5 to 20 μm such as calcium carbonate, titanium oxide, or glass with 100 parts by weight of polycarbonate, etc. can be mentioned.

[0011] As for the shape of light-scattering body 2, a column shape is desirable, and the cross section of the column may be cylindrical, oval, polygonal, rectangular, or tabular, but the usual form is cylindrical. Furthermore, the length and cross section area are appropriately selected, and in general, the length is in the range of 3 to 100 cm, preferably, in the range of 5 to 50 cm, and the cross section area is in the range of 0.05 to 100 cm^2, preferably, in the range of 1.5 to 20 cm^2. Furthermore, a reflective material used for reflecting light transmitted through light-scattering body 2 can be attached to the opposite end from that where the optical transmission tube of the light-scattering body 2 is connected.

[0012] Meanwhile, for the above-mentioned light transmission tube 3, any material can be used as long as it is a transparent material, and for example, organic resins such as polystyrene, polycarbonate, polymethacrylate, and silicone, and inorganic materials such as

glass, quartz, and transparent ceramics can be mentioned. In order to insert the light-scattering body, the inner diameter of the above-mentioned light transmission tube is made to be greater than the outer diameter of light-scattering body 2. The light-scattering body 2 and light transmission tube 3 may be in close contact, or an air gap may be included between them. It is desirable for the thickness of the light transmission tube 3 to be in the range of 0.5 to 5 mm, and approximately in the range of 0.5 to 2 mm is especially desirable. As described above, either the inner surface 3a or the outer surface 3b or both surfaces of the light transmission tube 3 have a roughened surface through which diffusion of the rays of light in all directions is achieved. In this case, the degree of roughness is in the range of 5 to 500 μm in terms of Rmax, and in the range of 10 to 200 μm is especially desirable. In order to produce the above-mentioned rough surface, known methods such as sand blasting, filing, or chemical action can be used.

[0013] [Test example] 0.01 parts by weight of crosslinked silicone particles with a mean particle diameter of 2.0 μm were added to a methacrylic resin, and subsequently molded into a rod (column) with a diameter of 12.9 mm and a length of 30 cm to produce a light-scattering body.

[0014] An optical transmission tube with a core diameter of 6 mm was connected to one end of the above-mentioned column-shaped light-scattering body, and a reflective material used for reflection of the transmitted light was attached to the other end; rays of light were transmitted from the optical transmission tube, and measurement of the luminance (Lux) versus the angle θ with respect to the axis of the light-scattering body was carried out as shown in Fig. 3, and measurement of the angular distribution of the emitted

light was carried out. The results obtained are shown in Fig. 4.

[0015] According to the results obtained, the angle of emission of the rays of light is low in the axial direction, and the luminance is high at an angle of approximately 30 degrees; furthermore, it was confirmed that the luminous distribution was reduced when the angle is increased, and a visual evaluation confirmed that the luminance was likely to be higher when observed at an angle from the front than when observed from the side.

[0016] Meanwhile, the above-mentioned column-shaped light-scattering body was inserted into a light transmission tube made of an acrylic with an inner diameter of 13 mm and having an outer diameter of 19 mm and having a roughened inner surface produced by sand blasting, and measurement was performed for the angular distribution of light emitted as above. The results obtained are also shown in Fig. 4. According to the results obtained, the directionality of the emission is greatly reduced, and a uniform angular distribution is achieved.

[0017]

[Effect of the invention] Uniform emission of light in all directions and uniform light emission as a whole can be achieved in the light-emitting material of the present invention.

[Brief description of figures]

[Fig. 1] A lateral cross section view of an example of the light-emitting material of the present invention.

[Fig. 2] A lateral cross section view of an example of a conventional light-emitting material.

[Fig. 3] An explanatory diagram showing the angle used for evaluation of the angular

distribution of light emission used in the test.

[Fig. 4] A graph that shows the angular distribution of light emission for the test example.

[Explanation of codes]

1 Light-emitting material

2 Light-scattering body

2a Transparent matrix

2b Transparent material

3 Transparent cylinder body

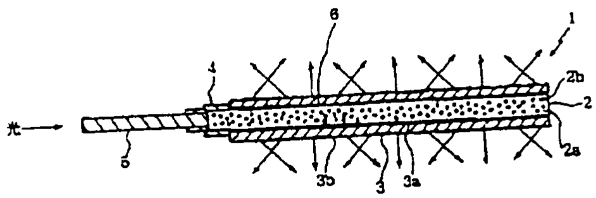
3a Cylinder inner surface

3b Cylinder outer surface

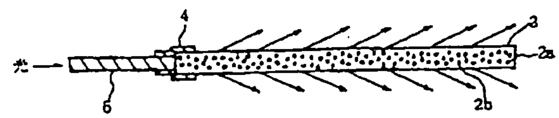
4 Joint

5 Optical transmission tube

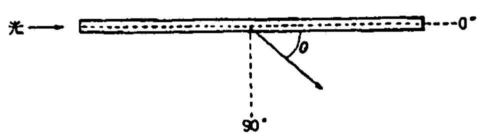
[Fig. 1]



[Fig. 2]



[Fig. 3]



[Fig. 4]

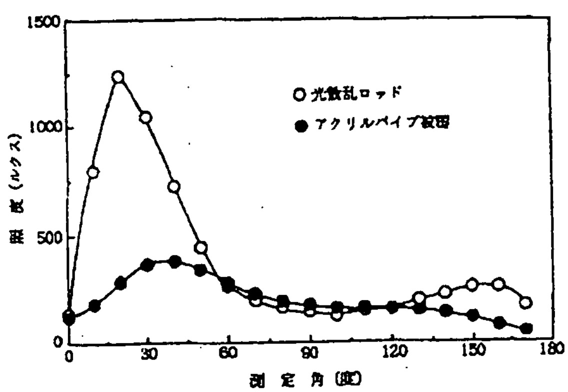


Fig. 4 legend

Vertical axis: Luminance (Lux)

Horizontal axis: Measurement angle (degrees)

White dots: Light-scattering rod

Black dots: Acrylic tube coating